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1.0 Introduction

This Technical Resource Guidance Document (Technical Guide) was written for use by environmental professionals seeking closure on sites through an Indiana Department of Environmental Management (IDEM) remedial program. This guidance document provides information on how to use the IDEM Risk Integrated System of Closure (RISC) within the authority of IDEM's remediation programs. The intent of the document is to provide (1) a default approach to site closure and (2) a framework for nondefault options if the default approach is not used. The primary goal of RISC is to ensure that risks to human health and the environment are reduced to a negligible level. A companion manual, the RISC User's Guide (User's Guide), offers a broader perspective on programmatic considerations as well as program-specific procedures. The User's Guide should be consulted for program-specific information on how the Technical Guide procedures may be applied.

Although RISC may be used to obtain information relevant to real estate transfers, RISC is not intended for this use, and IDEM is not a party to property transfers. Other methods and procedures, such as those specified by the American Society for Testing and Materials (ASTM), have gained broad, national acceptance in documenting environmental conditions for property transfers.

This chapter provides an overall introduction to RISC, defines key terms, discusses the purpose and applicability of RISC, and identifies exceptions to using the RISC default approach. This chapter also discusses constituent concentration limits, exposure pathways, and remedial approaches.

Non-Rule Policy

As a non-rule policy document, RISC guidance does not have the effect of law. Instead, it provides a systematic approach for consistently and rationally implementing the laws and rules that govern site investigation and closure. If a conflict exists between RISC and state or federal rules and statutes, the rules and statutes will prevail. Upon adoption of the Ground Water Quality Standards rule, IDEM will take appropriate steps to conform the ground water concepts in RISC (such as the Perimeter of Compliance) with the rule.

1.1 Definitions and Terms

The following concepts and terms are fundamental to RISC and to the development of this document: target risk levels, closure, default and nondefault approaches, site size and source area, and risk management. Each of these is discussed below.

1.1.1 Target Risk Levels

An important component of any risk assessment program is the acceptable target risk. For the RISC default approach, target risk levels have been set as follows:

- 1×10^{-5} cancer risk
- Hazard index of 1.0 by critical effect categories for noncarcinogenic effects

In a nondefault evaluation, cancer risk will be set within the range of 1×10^{-6} to 1×10^{-4}, depending on site-specific information, and the noncarcinogen hazard index will be set at 1.0 based upon critical effect categories (see Appendix 1, Table G).

1.1.2 Closure

RISC provides users with a well-defined process for reaching closure. RISC defines closure as follows:

> a. IDEM's written recognition that a party has demonstrated attainment of specific remedial or screening objectives (closure levels) for chemicals of concern at a particular area.
> b. Under the Resource Conservation and Recovery Act (RCRA), refers to a series of formal procedures required to end the operation of a permitted treatment, storage, or disposal (TSD) unit.

The *RISC User's Guide* is available as a companion document to this Technical Guide. The User's Guide provides program-specific information on how RISC may be applied. IDEM strongly recommends that users read the entire Technical Guide and any pertinent chapters of the User's Guide before applying RISC.

The regulatory and legal implications of achieving a particular closure level or levels vary depending on the remedial program involved. For example, achieving closure levels specified in an approved remediation work plan under Indiana's Voluntary Remediation Program leads to the issuance of a certificate of completion by IDEM and a covenant not to sue from the Governor. Achieving residential "clean closure" levels at a RCRA TSD unit means there are no further RCRA regulatory obligations for that unit. These different legal implications, the form of the closure documentation, and the level of repose achieved vary by remedial program, and are described in more detail in Chapter 6 below, in the User's Guide, and, ultimately, in the governing statutes and regulations.

Closure is granted when an area is suitable for a particular use. The closure document specifies the use and any limitations. Closure may be specific to a facility, a property, a regulated unit, or a specific area within a property.

Closure does not necessarily mean that the area in closure status is free from risk to human health and the environment with regard to *any* possible contaminant. Rather, closure is limited to the specific chemicals of concern addressed during the RISC evaluation. If certain contaminants, geographical areas, or environmental media were not specifically evaluated under RISC, closure will not apply to them. Closure is provided only for areas of a site that have either negligible contamination as demonstrated by sampling, or sufficient institutional controls.

To evaluate a site for closure, representative sampling and analysis is necessary to determine constituent concentrations in environmental media at the site. Representative sampling requires a statistically valid sampling approach; however, no sampling approach will provide absolute certainty with regard to contaminant concentrations in environmental media. The goal of representative sampling is to determine the confidence interval within which the true mean of the chemical of concern (COC) concentrations lie — and to keep the confidence interval as small as possible. These representative COC concentrations are compared to RISC closure levels to determine the extent of remediation, if needed.

1.1.3 Default and Nondefault Approaches to Closure

This Technical Guide differentiates between default and nondefault approaches to closure. *The term "default" refers to the use of any model, equation, constant, strategy, or process that is prescribed for general application as a standard within this RISC Technical Guide.* For example, the "default process" refers to the use of standard procedures described within this document, such as the default process for area screening, plume stability determination, closure sampling, and other activities.

Conversely, the term *"nondefault" refers to the use of any model, equation, constant, strategy, or process that is not prescribed for general application as a standard within this RISC Technical Guide*.

The nondefault process is not, by definition, superior or inferior to the default process. Nondefault procedures may be more applicable or advantageous for use at a particular site, and closure may be granted for nondefault approaches, when appropriate. Chapter 7 describes how nondefault procedures may be used as options within RISC. IDEM technical staff may require more time to review nondefault closure procedures and approaches, and more interaction with regulatory staff should be expected. In all cases, the validity of any nondefault approach must be adequately demonstrated before IDEM can approve such a submittal.

1.1.4 Site and Source Area

Some applications within RISC limit the source area to 0.5 acre or less. *"Source area (source)" is defined as the horizontal and vertical geographical area that exceeds default residential soil closure levels.*

The terms "source" or "source area" should not be confused with *"Site" is defined as a geographical area where environmental chemical of concern evaluation is desired.* This is usually the potential impact area of source area contamination. This may consist of a permitted unit, a facility, an entire property (depending upon program limitations), or adjacent property. Generally speaking, a source area is a specific area within a site. The only time these terms are synonymous is when the entire site, facility, or property is a suspected source area. A site may contain several separate source areas that may be evaluated individually under RISC.

1.1.5 Risk Management Policy

"Risk management" is defined in the RISC Technical Guide as the process of collecting, interpreting, and applying scientific data to ensure that risks to human health and the environment are reduced to a negligible level. To accomplish the RISC goal of negligible risk, the scientific data used to determine risk management decisions must be properly collected and interpreted. The primary goal of reducing risk involves preventing pollution from adversely impacting human health and the environment. A secondary risk management goal is to avoid unnecessary costs and burdens and to move sites through the RISC process to closure in a reasonable period of time

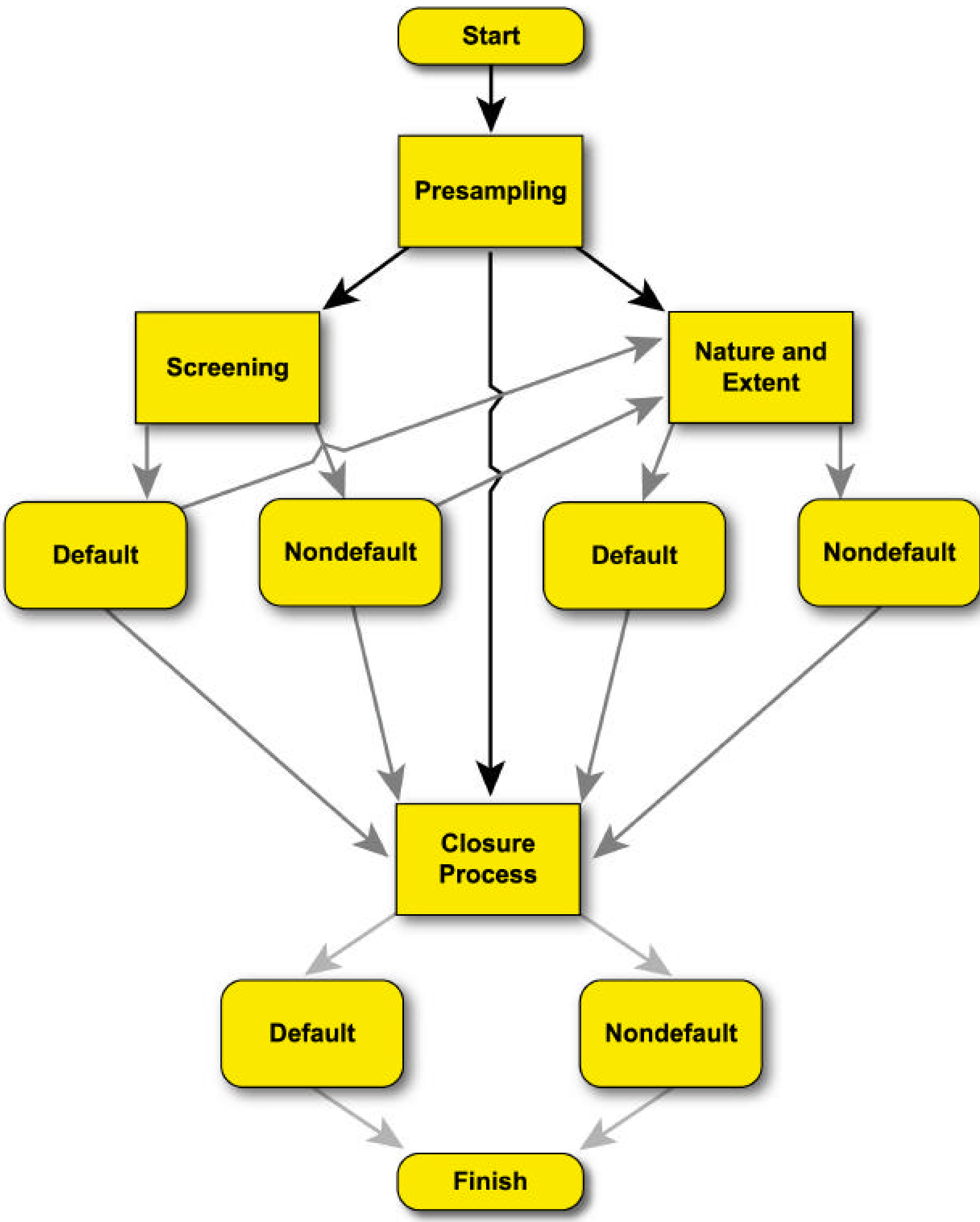
1.2 Purpose and Applicability

RISC is designed to serve as a flexible framework for achieving closure within the following existing IDEM programs:

- Leaking Underground Storage Tank Program (LUST)
- Voluntary Remediation Program (VRP)
- RCRA (Subtitle C) Permitting and Corrective Action Programs
- State Cleanup Program (SCP)

Figure 1-1 provides a flowchart that depicts the specific steps involved in the RISC process. As the figure shows, there are many acceptable approaches and many possible routes from beginning to end. Site-specific goals and time schedules should be evaluated to determine the best way to proceed. The advantage of RISC is its flexibility in the options available for closure.

Figure 1-1. The RISC Process



IDEM may require a post-closure response if new information indicates that site conditions could ultimately present a threat to human health or the environment.

Regardless of the specific program regulating a particular closure, the process involves the same basic steps. First, presampling is an essential activity at any site (see Chapter 2). These activities are conducted to gather available information on current and historic uses of the site. After presampling activities are complete, three courses of action are possible: (1) screening, (2) characterization of the nature and extent of contamination, and (3) closure. For each of these it is possible to use either default or nondefault procedures. Because IDEM has preapproved the default procedures, default submittals will likely move through the review and approval process more quickly than nondefault submittals.

Federal regulations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and RCRA Subtitle C specify the required parameters for site assessment and cleanup. For these sites, RISC provides supplemental guidance to be considered within the larger context of the federal regulations. In addition, RISC policies supplement existing rules by filling program gaps, particularly in the area of closure standards.

1.3 Exceptions to Using the RISC Default Approach

Because a risk assessment requires significant time for completion, RISC, (default or nondefault), is not suitable for situations that require immediate action or that otherwise present a potential acute or imminent risk. The following are examples of situations that must be remedied before it is appropriate to consider using a risk assessment:

- Releases covered under the Spill Rule (327 IAC 2-6.1)
- Potential acute exposures
- Presence of corrosive, flammable or toxic vapors
- Potential or actual contamination of a drinking water supply well

In some situations, RISC default procedures may not be appropriate because situations at the site are not consistent with RISC default assumptions. In these cases, a nondefault risk assessment is required. Examples of conditions and types of sites that require a nondefault approach include the following:

- Sites with COC source areas greater than 0.5 acre.

- Contaminated areas where bedrock is less than 10 vertical feet from the COC source. In this case, application of the soil-to-ground water partitioning model will require greater IDEM scrutiny and may be subject to additional requirements.

- Sites where vapors are present or intruding. As discussed above, acute, hazardous situations should be addressed immediately.

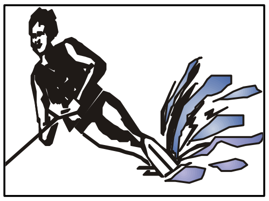
- Sites that contain or may be connected by a significant migration pathway to any geologically susceptible areas including karst terrains, mined areas, and other fractured rock geology where conduit ground-water flow occurs.

- Sites that contain, or may be connected by a migration pathway to any ecologically susceptible area.

- Sites where contamination may affect a wellhead protection area.

- Sites with an exposure pathway that differs from the default exposure pathway. Default exposure pathways are presented in Table 2-1 (see also Chapter 7, Tables 7-2 and 7-3).

Nondefault Exposure Pathways



Some examples of pathways not considered in the default process include recreational exposure from swimming in contaminated waters, consuming fish from contaminated waters, and inhaling vapors from contaminated industrial process water. If these pathways are present, they must be considered.

1.4 Constituent Concentration Limits

Risk-based closure levels are constituent concentrations calculated to be protective of human health. Limits have been established for risk-based closure concentrations, and some are listed in Appendix 1. A comprehensive list of constituent concentration limits is included on the following page.

1.5 Exposure Pathway Evaluation

Chemicals reach humans through soil, water, and air. These media serve as vehicles that carry chemicals to potential receptors. Such "exposure pathways" provide a means for contaminants to move through environmental media, ultimately creating an exposure. "Exposure route" refers to the ways that chemical contaminants transfer from environmental media into the body. RISC provides guidance for a default evaluation of contamination present in soil and ground water. The default evaluation is based on certain assumptions regarding exposure pathways and routes. These assumptions are necessary to calculate closure levels. Because closure levels identify constituent concentrations that are acceptable for human exposure, it is imperative that potentially contaminated areas be evaluated in a manner consistent with the assumptions of the calculations.

The subsections below discuss the evaluation of three default exposure pathways: soil exposure, ground water exposure, and construction worker occupational exposure.

1.5.1 Evaluating Soil Exposure Pathways

Exposure to soil contamination may occur by three main pathways: direct contact, migration to ground water, and other types, such as ingestion. It is necessary to evaluate each pathway when considering the actual and potential effect of soil COCs to human health.

- Direct contact with soil contamination may occur through any of the following exposure routes:

  - Direct contact with skin (dermal absorption route)

  - Inhalation of COC on soil particulates and dust (ingestion and inhalation routes)

  - Volatilization from soil into the air (inhalation route)

  - Soil consumption (ingestion and dermal absorption routes)

  - COC migration from soil to ground water, which could result in ground water ingestion, inhalation of volatile substances in ground water, and dermal absorption (such as showering or washing).

Additional Limits for Constituent Concentration

1. For each discrete sample, the sum of the concentrations of all organic constituents must not exceed the attenuation capacity of the soil, to be determined as follows:

   The sum of concentrations of residual organic constituents at each discrete sampling point must be less than the natural organic carbon fraction of the soil. If there is any information regarding the concentration of other organic constituents (in addition to chemicals of concern) such information should be included in the sum. The natural organic carbon fraction (f_{oc}) may be established by one of the following criteria:

   - A default value of 6,000 milligrams per kilogram (mg/kg) for soils within the top 2 feet of surface soils and a value of 2,000 mg/kg for soils more than 2 feet below ground surface

   - A site-specific value as measured by ASTM D2974-87, Nelson and Sommers, 1990, or by SW-846 Method 9060 for total organic carbon

   - Another method, approved by IDEM, which shows that the soil attenuation capacity is not exceeded

2. For each discrete sample, the concentration of any organic constituents remaining in the soil must not exceed the soil saturation limit (see Chapter 6).

3. For each discrete sample, no soil containing constituents shall exhibit a pH of less than or equal to 2.0 or greater than or equal to 12.5, as determined by (1) SW-846 Method 9040B: pH Electrometric for soils with 20 percent or greater aqueous (moisture) content, or (2) SW-846 Method 9045C: Soil pH for soils with less than 20 percent aqueous (moisture) content. These test methods are incorporated by reference in 329 IAC 3.1-1-7 (referencing 40 CFR 260.11).

4. For each discrete sample, no soil containing constituents shall exhibit any of the characteristics of reactivity for hazardous waste, as determined by 329 IAC 3.1-6 (referencing 40 CFR 261.23).

5. For each discrete sample, no soil shall contain a metal listed in the Default Closure Table at concentrations that exceed 10,000 mg/kg.

6. Free product must be removed from ground water to the maximum extent practicable. A constituent may not be present in ground water at concentrations that exceed the constituent's solubility concentration in the ground water.

(Cont. from 1-9)

– Other exposure pathways for metals in soils include ingestion, such as the consumption of produce grown in contaminated soil.

Direct contact routes (skin contact, dust inhalation, volatilization, and soil consumption) are associated with direct exposure to contaminated soil. Because the four direct contact routes often exist simultaneously for any potential receptor, their evaluation is often performed as one operation. Potential health effects from direct contact are considered by calculating one target remedial objective or closure level.

The exposure pathway that considers the migration of soil COCs to ground water assumes no direct soil exposure. Rather, COCs are assumed to leach from soil into ground water, where they become available for ingestion. Because the mechanisms differ for exposure from direct contact and migration to ground water, two separate soil assessments must be made to evaluate these pathways. The separate assessments usually result in two different closure levels for soil: one for direct contact and one for migration to ground water.

When evaluating potential health impacts to humans from direct contact, the evaluation will depend on the depth of potential activities relative to the exposure pathways. For example, if gardening is evaluated, the top 12 to 15 inches of surface soil (spade depth) should be considered. If construction of, or addition to, a building is anticipated, the top 15 feet of soil should be considered. Soil is often excavated to this depth to install building footers, and excavated soil may be used as fill in a low area. As a result, the new “surface soil” may not be safe for direct contact. Because of the uncertainty associated with identifying the potential for such activities, the default procedure for evaluating soil contamination requires the *lesser* of the direct contact and migration to ground water closure levels.

It may be possible to demonstrate that one or more pathways can be eliminated, and closure criteria may be based on direct contact or migration to ground water only. For example, if no building construction activity can be reasonably anticipated, there may be no need to consider the direct contact pathway to a depth of 15 feet - a shallower depth may be more appropriate (*e.g.* 0 - 8 feet). Pathways that have been eliminated from consideration are generally noted on the Environmental Notice (see Appendix 5); however, there may be cases where that is not necessary.

Consumption of produce grown in contaminated soil is a type of food web transfer from the plant-uptake pathway. The lack of empirical data for plant uptake of other chemical types limits the default evaluation of this pathway to metals only.

1.5.2 Evaluating Ground Water Exposure Pathways

Exposure to COCs in ground water can occur by three pathways and associated routes of exposure:

- Volatilization from water to air (inhalation route)
- Direct contact with skin (dermal absorption route)
- Water consumption (ingestion route)

Each of these pathways must be evaluated when considering the overall effect of ground water COCs and potential risks to human health. The default residential closure levels in RISC were calculated assuming (1) water consumption and (2) inhalation of volatiles during showering. Direct contact with skin was not considered in the calculation of default residential closure levels. Inhalation and ingestion routes are believed to be the predominant routes of exposure, and dermal contact was considered relatively insignificant. The RISC default commercial/industrial closure levels were calculated assuming reduced consumption, no showering, and a well ventilated workplace. These pathways should be reevaluated when calculating nondefault closure levels.

1.5.3 Evaluating Construction Worker Occupational Exposure

The preceding discussion of soil and ground water exposure pathways focuses on the protection of human health, assuming that exposure is related to either residential or commercial/industrial land use exposure criteria. Another category of soil exposure that is unrelated to land use is construction worker exposure. RISC assumes construction worker exposure activity within an excavation or trench.

Closure levels considered protective for construction workers are listed in the Default Closure Table (see Appendix 1, Table A). The construction worker closure levels must be compared with applicable soil closure levels to determine if the construction worker will be protected.

1.6 Background Considerations

Background sampling should be conducted any time that it is suspected that naturally occurring chemicals of concern are causing exceedences of closure levels at any site, or if it is suspected that off-site sources may be contributing to chemicals of concern detected at the site. Naturally occurring background contaminants are usually heavy metals. Very few organic chemicals are produced naturally at levels exceeding the analytical method's estimated quantitation limits.

In cases where it is needed, the background concentration should be established for each naturally occurring constituent that can be associated with activities at the site in question. Background concentrations should be determined for each soil horizon or appropriate interval, consistent with the source area investigative results. Background concentrations in soils can then be statistically compared with the source area concentrations.

Background soil borings and monitoring wells should be located in areas unaffected by past or present operations at the site and unaffected by other localized sources. Background soil samples must be collected from areas of similar soil type and land form as those found in the source areas. If more than one soil type or land form is present in the source area, an appropriate number of background samples should be collected to account for the variability. When possible, background soil samples should be collected in natural, undisturbed soil from the same soil horizon and depth as the source areas.

Background soil sampling may be accomplished in one of two ways depending upon the site conditions:

- a minimum of four background soil borings are performed, and samples are collected at intervals suitable for comparison with source area, or
- a minimum of four background soil borings are performed, and samples are collected from each distinct soil horizon.

Analytical results are averaged for each interval or horizon as appropriate. The mean plus one standard deviation should be compared to individual source area concentrations for each soil interval or horizon. If the coefficient of variation (CV, see Equation 7-7 on next page) for the background samples exceeds 1.2, additional sampling or other measures may be necessary.

Soil horizons and soil types will need to be evaluated and documented within the background and source areas. If specific soil horizons are not present due to such things as anthropogenic alternation, it is advisable to consult IDEM staff for an alternate approach.

In the case of naturally occurring chemicals of concern, the appropriate standard for closure is the greater of either the background level or the risk based closure level. Source areas which exceed risk based closure levels due to background chemicals of concern that are attributed to anthropogenic sources require a method to control potential human exposure.

To establish background concentrations for ground water, it is necessary to determine the number and kinds of samples that are appropriate for the statistical test employed, which is generally the 95% upper confidence limit of the mean of quarterly samples from each well. The sample size should be as large as necessary to ensure that the background samples are representative of the flow zone. Background ground water samples must be obtained from appropriate flow zones and locations to ensure that the samples represent ground water unaffected by on-site contamination sources. The distinct geological and hydrological characteristics of the saturated material must be described and correlated for each appropriate flow zone in the source and background areas.

Coefficient of Variation

Equation 7-7.

$$CV = \frac{s}{m_1}$$

Where:

s = Population standard deviation
m = Population mean

1.7 Remedial Approaches

Remedial approaches to site closure may or may not include institutional controls. Both types of approaches are discussed below.

1.7.1 Remedial Approaches Without Institutional Controls

Remedial approaches for achieving closure that do not involve institutional controls include (1) removal of the contaminated media to residential closure levels and (2) treatment through physical, chemical, or biological methods.

Removal is the excavation and shipment of contaminated media to an appropriate location for processing or deposition. The most common example of removal is the excavation of contaminated soil. Any soil excavated as part of a removal action where COC concentrations exceed residential default closure levels must be managed in accordance with applicable solid or hazardous waste rules.

Treatment permanently reduces contaminant concentrations to levels equal to or less than the designated closure levels. Examples of decontamination technologies that qualify as treatment methods include bioremediation, soil washing, thermal destruction, thermal desorption, and ground water recovery and treatment.

Removal and treatment are both permanent processes. When contaminant reduction or elimination control measures are used, institutional controls are not necessary.

1.7.2 Remedial Approaches With Institutional Controls

An institutional control is a legal mechanism for maintaining a land use restriction, either through activity restrictions or engineering controls When any land use restriction is employed, an institutional control must be in place (see Appendix 5 and Chapter 6 for a more detailed discussion). For site closure that relies on engineering controls and activity restrictions, a closure plan must be developed that details how engineering controls and reporting will be implemented and maintained. The remainder of this section discusses activity restrictions and engineering controls.

Activity Restrictions

If a remedy does not eliminate all potential exposures associated with the contaminated media, then an activity restriction may be used to prevent such exposures. Activity restrictions prohibit operations that could result in exposure to COCs. For example, an activity restriction could require that no drinking water wells be constructed within a certain area or screened above a certain depth. These restrictions may be accomplished through an environmental notice, a ground water ordinance or nondefault procedures. See Appendix 5 for information on environmental notice and ground water ordinances, and Chapter 7 for information on nondefault criteria.

When areas are remediated to commercial/industrial closure levels, a commercial/industrial land use designation must be recorded on the property deed. This designation is one type of institutional control used to notify all future landowners that the property meets industrial/commercial closure levels, but that it may not be suitable for residential use.

Engineering Controls

Engineering controls are physical controls that prevent exposure to contaminated media or prevent COCs from migrating further. Any physical treatment method that provides an appropriate barrier but does not permanently and irreversibly decrease COC concentrations to closure levels throughout the contaminated media is considered an engineering control. For example, construction of a watertight cap to prevent infiltration into a source area is an engineering control that will limit COC migration from soil to ground water. Concrete and asphalt surfaces are not considered impervious materials, and they will not prevent infiltration; nevertheless, they may prevent direct contact with soil.

Some engineering controls that eliminate exposure pathways include protective caps or covers, slurry walls, extraction wells, or fencing. Some controls, such as an asphalt parking lot, may already exist at a site. Obligations for ongoing repair and maintenance of these existing structures may be necessary if they are to serve as engineering controls for the site.

Public Notice and Comment

Conscientious efforts to involve the community in the decision-making process will be considered essential for the acceptance of the remedy. It is the responsibility of the party seeking closure to inform the neighbors and other potentially affected parties of all relevant details regarding the proposed closure. The RISC User's Guide provides additional information regarding programmatic considerations.